entertained by Wagner, Bischoff, Barry, and Wharton Jones, concerning the membranous nature of that portion of the ovule known as the *zona pellucida*.

6. That the oil-globules of the yelk are either enclosed in a distinct membrane, or else that a structureless solid material pervades the entire substance of the vitelline body, and so binds the several component elements of it together.

7. That the recognition of the germinal vesicle removes some doubts concerning its appearance and position in the germ-mass.

May 8, 1851.

The EARL OF ROSSE, President, in the Chair.

Professor Owen delivered the Croonian Lecture, being the substance of his paper "On the Megatherium."—Part II. Received May 6, 1851.

In his lecture the author premised a brief sketch of the successive steps which had led to the knowledge of the Megatherium acquired at the date of his researches, and of the different hypotheses which had been broached of its affinities, habits and food. He then recounted the mode of the acquisition of the complete skeleton, and of its articulation, at the British Museum, and commenced its description by the vertebræ of the trunk. These consist of 7 cervical, 16 dorsal, 3 lumbar, 5 sacral, and 18 caudal vertebræ. The first to the fifth dorsal vertebræ are characterized by having the ordinary number of articular processes (zygapophyses), two before and two behind; and by having three articular surfaces for the ribs on each side, one on the centrum, one on the neurapophysis, and one on the diapophysis. The sixth dorsal vertebra has an accessory zygapophysis between the posterior pair; the thirteenth dorsal has one between the anterior pair; the seventh to the twelfth inclusive have the accessory median zygapophysis between both the anterior and posterior pairs of the ordinary zygapophyses. The fourteenth and succeeding dorsals have no costal surface on the diapophysis or centrum. The fifteenth has both metapophysis and anapophysis—the latter with an articular surface: the sixteenth superadds the parapophysis with an articular facet.

The lumbar vertebræ lose the costal surface on the centrum, and retain the metapophyses, anapophyses and parapophyses. The nature of these accessory processes was explained by reference to the descriptions and figures of the exogenous processes of vertebræ in Part I. of the present Memoir.

The characteristics of the cervical vertebræ were next detailed.

Of the five anchylosed sacral vertebræ, three are confluent with the iliac bones, and two with the ischia.

The fourteen anterior caudals are characterized by articular surfaces for hæmapophyses. These elements are separate from each other in the first caudal, and confluent as usual at their distal ends, forming a 'chevron-bone' in the others. The posterior zygapophyses lose their articular surfaces in the eleventh caudal; the anterior

ones disappear in the twelfth: the metapophyses have subsided in the fifteenth. The neural canal is unclosed above in the sixteenth; and the vertebra is reduced to its central element in the last two caudals.

The skull is remarkable for its small proportional size, for its long and slender cranial portion, its large and complex zygomatic arches, its broad truncate facial part, with the slender produced premaxillaries, and for the great depth of the middle of the lower jaw.

The mastoid element developes a large tuberous process and a deep semicircular articular cavity for the stylohyal. The malar bone sends down a long process outside the lower jaw. The number of teeth is $\frac{5-5}{4-4}=18$, the fifth in the upper jaw being the smallest. They are alike in structure, and differ but little in shape: thegrinding surface in most is crossed by two transverse ridges, the summits of which are formed by hard dentine; the rest of the tooth being composed of a central body of vaso-dentine and a peripheral mass of vascular cement. The microscopic characters of these several constituents of the teeth were then described. Each tooth is deeply implanted in the jaw, where it terminates without dividing into fangs, by a widely open pulp-cavity for a persistent matrix, ensuring perpetual growth. The stylohyal bone has the form of a hammer, with a long, slightly bent handle; one part of the head being thickened and rounded for articulation with the cavity in the mastoid.

The scapula presents almost the form of a trapezium, with the inferior angle bent outwards, increasing the depth of the subspinal fossa: there is a rudiment of a second spine, below the normal one: the acromion is expanded, produced and confluent with the coracoid; and the supraspinal fossa is perforated by a circular aperture. The clavicle has a well-marked sigmoid flexure, equally-developed obtuse extremities, without any articular surface. The humerus is remarkable for the enormous development of ridges for the attachment of the muscles, especially at its distal end: the inner condyle is not perforated as in the *Megalonyx*; it is devoid of a medullary cavity.

The ulna and radius are next described. The carpus consists of seven bones, three of which are proper to the first row, three to the second, and one is common to both; the latter answers to the 'scaphoides' and 'trapezium' in the human wrist, and articulates with the radius above, and the rudiment of the metacarpal of the pollex below.

Only four digits are developed, the first or 'pollex' being obsolete. The 'index' or second digit has three phalanges, the last supporting a large claw, and being twice as long as the two preceding phalanges. The proximal and middle phalanges of the 'digitus medius' are confluent. The ungual phalanx is shorter than that of the index, but has twice its vertical breadth. The metacarpals progressively increase in length from the first to the fifth. The fourth digit or 'annularis' has three phalanges, the last being unguiculate and longer than that of the 'medius.' The fifth digit has only two very short rounded phalanges, which were doubtless buried in a thick callous outer border of the foot, on which the Megatherium rested when applying the foot to the ground.

The pelvis shows the conversion of the ischiadic notch into a foramen by the anchylosis of the ischia with the posterior sacral vertebræ, and the union of the ossa pubis at a short anteriorly produced symphysis. The ilia are extraordinary for their vast breadth, and the thickness of the rugged labrum; indicative of the enormous muscular forces, of which this conspicuous part of the skeleton was the centre.

The femur is hardly less remarkable for its breadth and strength. The head is devoid of an impression for the ligamentum teres: but from the dimensions of the hemispheroid cavity receiving it, the author calculates that the muscles are aided in retaining the head of the femur in its place by an atmospheric pressure, with the barometer at 30 in., of not less than 660 pounds. At the distal end of the femur there is a great angular projection above the outer condyle. The rotular surface is continuous with that upon the outer condyle, but not with the inner one. The tibia and fibula are anchylosed together at both their extremities. Besides the patella in front of the knee-joint, there is a sesamoid 'poplitella' behind, wedged between the outer condyle and the tibia; which was doubtless imbedded at its base in the femoro-tibial articular capsule, and gave insertion to the tendon of the *popliteus* muscle. This sesamoid is not to be confounded with the 'fabella,' developed in many quadrupeds in the origin of the gastrocnemius, behind one or both condyles of the femur. The most peculiar feature in the tibia of the Megatherium is the form of the distal articular surface: especially the large and deep hemispherical excavation on the inner part of that surface for an unusually secure interlocking of the foot to the leg.

The bones of the tarsus are six in number in the Megatherium, and the astragalus offers corresponding peculiarities with those of the tibia with which it is articulated, and also remarkable modifications for the articulation of the naviculare and calcaneum. In the calcaneum, the length and strength of the hinder prominence forming the great lever for the extension of the foot, are amongst its most striking characteristics. These, with those of the other bones of the tarsus, are minutely detailed. There is no digit answering to the great toe or 'hallux,' nor any trace of the 'os cuneiforme' for that toe. The innermost of the 'ossa cuneiformia' answers to the middle one, and if any rudiment of the second toe ever existed independently, it has coalesced with that cuneiform bone: but this cannot be supposed to represent both middle and internal cuneiform bones and their digits blended together, as Cuvier supposed. There are no little bones missing from the inner side of the middle cuneiforme, as Pander and D'Alton conjectured. The first or innermost distinct metatarsal bone is that of the toe answering to the third, or digitus medius, in the pentadactyle foot: it is a short thick irregular wedge-shaped bone, with a large triangular concave base for the 'ecto-cuneiforme'; a semicircular flattened surface on the outer side for the fourth metatarsal, and a small semi-elliptic flat surface on the inner side for the 'meso-cuneiforme'. The distal end of the bone presents a strong median vertical obtuse ridge, dividing two

vertically elongated slightly concave surfaces, to which the anchylosed proximal and middle phalanges of the strong claw-bearing digit articulate. The ungual phalanx is shorter in proportion to its depth, than in the digitus medius of the fore-foot, and differs in the greater breadth of the upper part of the claw-sheath, and in the straighter cone, or bony core, which supported the claw. The metatarsals of the fourth and fifth toes are much larger than that of the third; but they support mere rudiments of digits reduced in each to two stunted phalanges, which were doubtless buried like those of the outer digit in the fore-foot in a kind of callous hoof.

Having completed the description of the skeleton, which is illustrated by an extensive series of accurate and highly finished drawings, the author proceeds to the comparison of the modifications of the osseous structure of the gigantic extinct animal with that in other known existing and extinct species of the class Mammalia.

The teeth agree in number, kind, mode of implantation and growth, with those of the Sloth, and their structure is a modification of that peculiar to the Sloth-tribe. All the modifications of the skull relating to the act of mastication, especially the large and complex malar bone, repeat the peculiarities presented by the existing Sloths. There are the same hemispheric depressions for the hyoid bone in the Megatherium as in the Sloth. In the number of cervical vertebræ the Megatherium, like the two-toed Sloth, agrees with the Mammalia generally. In the accessory articular surfaces afforded by the anapophyses and parapophyses of the hinder dorsal and lumbar vertebræ, the Megatherium resembles the Ant-eaters (*Myrmecophagæ*): but it does not resemble the Armadillos (*Dasypus*) in having long metapophyses, the peculiar development of which in those loricated *Bruta* has a direct relation to the support of their bony dermal armour. In the mesozygapophyses of the middle dorsal vertebræ the Megatherium is peculiar. In the small extent of the produced and pointed symphysis pubis it resembles the Sloths; and in the junction of both ilium and ischium with the sacrum, it manifests a character common to the Edentate order; but in the expanse and massiveness of the iliac bones, it can only be compared with other extinct members of its own peculiar family of Phyllophagous Edentata. Its habits necessitating a strong and powerful tail, we find this resembling in its bony structure that of other Edentata with a similar appendage, especially in the independency of the two hæmapophyses of the first caudal, a character which obtains in the Great Ant-eater and in some Armadillos; but this is no evidence of direct affinity to either of these families; the habits of the small arboreal Sloths render their eminently prehensile limbs sufficient for their required movements, and the tail is wanting. Had that appendage been proportionally as large as in the Megatherium, we cannot suppose that the caudal vertebræ would have materially differed from those of other Edentata.

In the coalescence of the anterior vertebral ribs with the bony sternal ribs, the Megatherium resembles the Sloths. This essential affinity is still more marked in the peculiarities of the scapula and

of the carpus. In the *Myrmecophaga jubata*, the scaphoid is distinct: in the *Manis* it coalesces with the lunare: in the *Dasypus gigas* the trapezoides is anchylosed to the second metacarpal: in the *Das. sexcinctus* it has coalesced with the trapezium. Not any of these characteristics are manifested by the Megatherium: its carpus repeats the peculiarities of that in the Sloths, viz. the reduction of the number of carpal bones to seven by the coalescence of the scaphoid with the trapezium. The first digit (pollex), which is retained in the Anteaters and Armadillos, is obsolete in the Megatherium as in the Sloths and Orycteropus: three digits are fully developed and armed with claws, as in the *Bradypus tridactylus*; and the fifth, though incomplete in the Megatherium, is better developed, because it was required in the ponderous terrestrial Sloth for its progression on level ground. In no existing ground-dwelling Edentate is the fifth digit deprived of its ungual phalanx, as in the Megatherium. The bones of the fore-foot of that extinct animal are thus seen to be modified mainly after the type of the *Bradypodidæ*.

The long bones of all the limbs are devoid of medullary cavities, as in the Sloths. The femur lacks the ligamentum teres as in the Sloths. The fibula is anchylosed to the tibia at both ends in Megatherium, as in *Dasypus*; but this is not the case in the closely-allied extinct Megatherioids called *Mylodon*, *Megalonyx* and *Scelidotherium*, a fact which diminishes the force of the argument which Cuvier deduced from the coalesced condition of the bones in the Megatherium in favour of its affinities to the Armadillos. The semi-inverted but firm interlocking articulation of the hind-foot to the leg shows the peculiarities of that joint in the Sloths exaggerated, and departs further from its characteristics in other Edentata. In all the existing *Edentata*, save the Sloths, the hind-foot is pentadactyle, and four of the toes have a long claw, even in the little arboreal *Myrmecophaga didactyla*: the departure by degradation from the pentadactyle type is a peculiar characteristic of the Sloth-tribe in the order. It is carried further in the same direction in the great extinct terrestrial Sloths. In these the mutilation of the foot has commenced on the outer side by the removal of the ungual phalanx from the fifth and fourth toes; but this accompanied by modifications which adapt these toes to the important office of support and progression of the body on level ground. In the scansorial Sloths, the three middle digits being equally developed for prehension, one toe on the outer and one on the inner side of the foot, are reduced to their metatarsal basis. In the Megatherium the mutilation of the foot on the inner side is carried to a greater extent; the innermost toe or hallux, with its entocuneiform bone, is wholly removed: the second toe is represented, like the first in the Sloths, by its cuneiform bone and a coalesced rudiment of the metatarse: and it is only the third toe or medius that repeats the condition of the claw-bearing toes in the climbing Sloths.

Finally, the author enters upon the question of the habits and food of the Megatherium. Guided by the general rule that animals having the same kind of dentition have the same kind of food, he

concludes that the Megatherium must have subsisted, like the Sloths, on the foliage of trees; but that the greater size and strength of the jaws and teeth, and the double-ridged grinding surface of the molars in the Megatherium, adapted it to bruise the smaller branches as well as the leaves, and thus to approximate its food to that of the Elephants and Mastodons. The existing Elephants and the Giraffe are specially modified to obtain their leafy food; the one being provided with a proboscis, and the entire frame of the lofty Giraffe adapting it to browse on branches above the reach of its largest ruminant congeners. If the Megatherium possessed, as Cuvier conjectured, a proboscis, it cannot, judging from the suborbital foramina, have exceeded in size that of the Tapir, and could only have operated upon branches brought near its mouth. Of the use of such a proboscis in obtaining nutritious roots, on the prevalent hypothesis that such formed the sustenance of the Megatherium, it is not easy to speculate: the hog's snout might be supposed to be more serviceable in obtaining those parts of vegetables; but no trace of the prænasal bone exists in the skull. A short proboscis would be very useful in rending off the branches of a tree prostrated and within reach of the low and broad-bodied Megatherium, and it would be aided in this act by the tongue, of which, both the hyoid skeleton, by its strength and articulation, and the foramina for the muscular nerves by their unusual area, attest the great size and power.

As regards the limbs, the Megatherium differs from the Giraffe and Elephant in the unguiculate character of certain of its toes, in the power of rotating the bones of the fore-arm, in the corresponding development of supinator and entocondyloid ridges in the humerus, and in the possession of complete clavicles. These bones are requisite to give due strength and stability to the shoulder-joint for varied actions of the fore-arm, as in grasping, climbing and burrowing: but they are not essential to scansorial or fossorial quadrupeds; the Bear and the Badger have not a trace of clavicles, and the mere rudiments of these bones exist in the Rabbit and the Fox. We must seek, therefore, in the other parts of the organization of the Megatherium, for a clew to the nature of the actions by which it obtained its food. In habitual burrowers the claws can be extended in the same plane as the palm, and they are broader than they are deep. In the Megatherium the depth of the claw-phalanx exceeds its breadth, especially in the large one of the middle finger; and they cannot be extended into a line with the metacarpus, but are more or less bent. Thus, although they might be used for occasional acts of scratching up the soil, they are better adapted for grasping; and the whole structure of the fore-foot militates against the hypothesis of Pander and D'Alton, that the Megatherium was a burrowing animal. The same structure equally shows that it was not, as Dr. Lund supposes, a scansorial quadruped; for, in the degree in which the foot departs from the structure of that of the existing Sloths, it is unfitted for climbing; and the outer digit is modified, after the ungulate type, for the exclusive office of supporting the body in ordinary terrestrial progression. It may be inferred from the diminished curvature and

length, and from the increased strength and the inequality of the claws, especially the disproportionately large size of that weapon of the middle digit, that the fore-foot of the Megatherium was occasionally applied by the short and strong fore-limb in the act of digging; but its analogy to that of the Ant-eaters teaches that the fossorial actions were limited to the removal of the surface-soil, in order to expose something there concealed, and not for the purpose of burrowing. Such an instrument would be equally effective in the disturbance of roots and ants; it is, however, still better adapted for grasping than for delving. But to whatever task the partially unguiculate hand of the Megatherium might have been applied, the bones of the wrist, fore-arm, arm and shoulder, attest the prodigious force which would be brought to bear upon its execution. The general organization of the anterior extremity of the Megatherium is incompatible with its being a strictly scansorial or exclusively fossorial animal, and its teeth and jaws decidedly negative the idea of its having fed upon insects; the two extremes in regard to the length of the jaws are presented by the phyllophagous and myrmecophagous members of the Edentate order, and the Megatherium in the shortness of its face agrees with the Sloths.

Proceeding then to other parts of the skeleton for the solution of the question as to how the Megatherium obtained its leafy food, the author remarks that the pelvis and hind limbs of the strictly burrowing animals, *e.g.* the Mole, are remarkably slender and feeble, and that they offer no notable development in the Rabbit, the Orycterope, or other less powerful excavators. In the climbing animals, as *e.g.* the Sloth and Orang, the hind-legs are much shorter than the fore-legs, and even in those Quadrumana in which the prehensile tail is superadded to the sacrum, the pelvis is not remarkable for its size or the expansion of the iliac bones. But in the Megatherium the extraordinary size and massive proportions of the pelvis and hind limbs arrest the attention of the least curious beholder, and become eminently suggestive to the physiologist of the peculiar powers and actions of the animal. The enormous pelvis was the centre whence muscular masses of unwonted force diverged to act upon the trunk, the tail, and the hind legs, and also by the 'latissimus dorsi' on the fore-limbs. The fore-foot being adapted for scratching as well as for grasping, may have been employed in removing the earth from the roots of the tree and detaching them from the soil. The fore-limbs being well adapted for grasping the trunk of a tree, the forces concentrated upon them from the broad posterior basis of the body may have co-operated with them in the labour, to which they are so amply adapted, of uprooting and prostrating the tree. To give due resistance and stability to the pelvis, the bones of the hind-legs are as extraordinarily developed, and the strong and powerful tail must have concurred with the two hind-legs in forming a tripod as a firm foundation for the massive pelvis, and affording adequate resistance to the forces acting from and upon that great osseous centre. The large processes and capacious spinal canal indicate the strength of the muscles which surrounded the tail,

and the vast mass of nervous fibre from which those muscles derived their energy. The natural co-adaptation of the articular surfaces shows that the ordinary inflection of the end of the tail was backwards as in a *cauda fulciens*, not forwards as in a *cauda prehensilis*. Dr. Lund's hypothesis, therefore, that the Megatherium was a climber and had a prehensile tail, is destroyed by the now known structure of that part.

But viewing, as the author conceives, the pelvis of the Megatherium as being the fixed centre towards which the fore-legs and fore-part of the body were drawn in the gigantic leaf-eater's efforts to uprend the tree that bore its sustenance, the colossal proportions of its hind extremities and tail lose all their anomaly, and appear in just harmony with the robust claviculate and unguiculate fore-limbs with which they combined their forces in the Herculean labour.

The author then referred to the *Mylodon robustus*, a smaller extinct species of the same natural family of phyllophagous *Bruta*, and to the additional arguments derivable from the skeleton of that animal in favour of the essential affinity of the Megatherium to the Sloths; and the light which the remarkable healed fractures of the skull of a specimen in the Museum of the College of Surgeons threw upon the habits and mode of life of the species.

Finally, with reference to the hypothesis of the German authors and artists of the degeneration of the ancient Megatherioids of South America into the modern Sloths, the author remarked that the general results of the labours of the anatomist in the restoration of extinct species, viewed in relation to their existing representatives of the different continents and islands, commonly suggested the idea that the races of animals had deteriorated in point of size. Thus the palmated Megaceros is contrasted with the Fallow-deer, and the great Cave-bear with the actual Brown Bear of Europe. The huge Diprotodon and Nototherium afford a similar contrast with the Kangaroos of Australia, and the towering Dinornis and Palapteryx with the small Apteryx of New Zealand. But the comparatively diminutive aboriginal animals of South America, Australia and New Zealand, which are the nearest allies of the gigantic extinct species respectively characteristic of such tracts of dry land, are specifically distinct, and usually by characters so well marked as to require a subgeneric division, and such as no known or conceivable outward influences could have progressively transmuted. Moreover, as in England, for example, our Moles, Water-voles, Weasels, Foxes and Badgers, are of the same species as those that co-existed with the Mammoth, Tichorrine Rhinoceros, Cave Hyæna, Bear, &c.; so likewise the remains of small Sloths and Armadillos are found associated with the Megatherium and Glyptodon in South America; the fossil remains of ordinary Kangaroos and Wombats occur together with those of gigantic herbivorous marsupials; and there is similar evidence that the Apteryx existed with the Dinornis: and the author offered the following suggestions as more applicable to or explanatory of the phenomena than the theory of transmutation and degradation. He observed, that in proportion to the bulk of an animal is the difficulty

of the contest which, as a living being, it has to maintain against the surrounding influences which are ever tending to dissolve the vital bond and subjugate the organised matter to the ordinary chemical and physical forces. Any changes, therefore, in the external circumstances in which a species may have been created to exist, will militate against that existence in probably a geometrical ratio to the bulk of such species. If a dry season be gradually prolonged, the large mammal will suffer from the drought sooner than the small one; if such alteration of climate affect the quantity of vegetable food, the bulky Herbivore will first feel the effects of the stinted nourishment; if new enemies are introduced, the large and conspicuous quadruped or bird will fall a prey, whilst the smaller species might conceal themselves and escape. Smaller quadrupeds are usually, also, more prolific than larger ones. The actual presence therefore of small species of animals in countries where the larger species of the same natural families formerly existed, is not to be ascribed to any gradual diminution of the size of such larger animals, but is the result of circumstances which may be illustrated by the fable of 'the oak and the reed'; the small animals have bent and accommodated themselves to changes under which the larger species have succumbed.

May 15, 1851.

The EARL OF ROSSE, President, in the Chair.

The following papers were read:—

1. "Note relating to M. Foucault's new mechanical proof of the Rotation of the Earth." By C. Wheatstone, Esq., F.R.S., Corresponding Member of the Academies of Science of Paris, Berlin, Brussels, Turin, Rome, Dublin, &c. Received May 15, 1851.

The experiment which led M. Foucault to his ingenious and interesting researches relating to the rotation of the earth, is stated by him thus:—"Having fixed on the arbor of a lathe and in the direction of the axis, a round and flexible steel rod, it was put in vibration by deflecting it from its position of equilibrium and leaving it to itself. A plane of oscillation is thus determined, which, from the persistence of the visual impressions, is clearly delineated in space; now it was remarked that, on turning by the hand the arbor which serves as a support to this vibrating rod, the plane of oscillation is not carried with it."

This persistence of the plane of oscillation of a vibrating rod, notwithstanding the rotation of the point to which its end is fixed, does not appear to have hitherto been made the subject of philosophical observation. Ordinary notions even seem to have been opposed to this now recognised fact. Chladni in his treatise on Acoustics, in the chapter "On the co-existence of vibrations with other kinds of motion," states as follows:—

"Vibratory motions may co-exist with all other kinds of motions